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Phonetic characteristics of English, German, Spanish, and French vowels are compared and contrasted in this third of a series of articles on general phonetic characteristics of American English. Much attention is given to acoustic and articulatory description. Vowel distribution, frequency, and duration are discussed. New vowel sounds for the speaker of English are identified in the other languages. Neutral vowel position, loss of vowel color, consonant anticipation, diphthongization, vowel color and syllable type, attack and release, and nasality are considered. For related documents see FL 000 782 and FL 000 784. (AF)

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COMPARING THE VOCALIC FEATURES OF ENGLISH, GERMAN, SPANISH AND FRENCH

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FL 000 781

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COMPARING THE VOCALIC FEATURES OF ENGLISH, GERMAN, SPANISH AND FRENCH [1])

Pierre Delattre, University of California

Le professeur Delattre poursuit sa série d'articles résumant ses recherches sur la description phonétique comparée de l'anglais (américain), de l'allemand, de l'espagnol et du français.

Il s'agit ici d'une description des systèmes vocaliques de chacune de ces langues.

La cinéradiographie d'une part, l'analyse et la synthèse acoustiques de l'autre ont permis de déterminer les réalisations les plus caractéristiques (c'est-à-dire les plus facilement identifiables par les sujets appartenant à ces groupes linguistiques).

Cela fait, on peut comparer ces réalisations d'une langue à une autre.

Cette comparaison met en lumière les différences phonologiques et phonétiques entre l'anglais d'une part, l'allemand, l'espagnol et le français de l'autre: différences d'articulation; phénomènes particuliers à l'une ou l'autre langue; différences de distribution et de fréquence parmi les voyelles; le rôle distinctif de durée des voyelles; positions vocaliques neutres; rapports de couleur vocalique et de position d'accent; anticipation de consonnes; diphthongues et diphthongaison; voyelles en syllabes ouvertes ou fermées; intensité d'attaque et de "relâchement" vocalique; fonction distinctive de la nasalisation. L'analyse de ces différences et de ces contrastes permet de prévoir les difficultés auxquelles se heurtera un étudiant américain qui s'efforce d'apprendre une de ces trois langues.

Dies ist der dritte Beitrag einer Artikelserie über die allgemeinen phonetischen Merkmale des amerikanischen Englisch, verglichen mit denen des Deutschen, Spanischen und Französischen.

Nach einer Beschreibung der Forschungstechnik in vier Unterabteilungen – radiografische Beobachtung, spektrografische Analyse, spektrografische Synthese und statistische Übersicht (IRAL I/2, 85–97) – wurde im zweiten Beitrag die Prosodie der vier Sprachen verglichen (IRAL I/3–4, 193–210).

Dieser dritte Beitrag behandelt die Darstellung der charakteristischen phonetischen Merkmale der Vokale der vier Sprachen. Dabei werden die Unterschiede zwischen den Sprachen besonders hervorgehoben. Die vergleichende Untersuchung der Vokale wird in folgenden Abschnitten durchgeführt: 1. Beschreibung der Artikulation, 2. Beschreibung der Akustik, 3. Neue Vokaltöne, 4. Vokalanordnung, 5. Auftrittshäufigkeit von Vokalen, 6. System der Vokaldauer, 7. Neutrale Stellung, 8. Verlorengehen der Vokalfarbe, 9. Wirkung der Vorwegnahme von Konsonanten, 10. Doppellautung, 11. Vokalfarbe und Silbentyp, 12. Vokalanfall und Auslösung, 13. Nasale Merkmale von Vokalen.

Die vorliegenden Ergebnisse sind naturgemäß Teilresultate, doch ist zu hoffen, daß dort, wo die Forschung wenigstens fortgeschritten ist, aus dem Verständnis des Forschungsziels dem Sprachlehrer bereits eine Hilfe erwächst.

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[1]) The research reported herein was performed pursuant to a contract with the United States Office of Education, Department of Health, Education and Welfare.

This is the third in a series of articles on the general *phonetic* characteristics of American English as compared with those of German, Spanish and French. Following a description of the research technique we have developed (*IRAL*, I/2: 85–97, 1963), and which is four-fold – radiographic observation, spectrographic analysis, spectrographic synthesis and statistical survey – the prosodic features of those four languages were compared (*IRAL*, I/3–4: 193–210, 1963). Now the phonetic features that characterize the *vowels* of each of the four languages will be presented, with emphasis on what distinguishes one language from the others.

Our comparative study of vowels is in progress under the following subdivisions: 1. Articulatory description. 2. Acoustic description. 3. New vowel sounds. 4. Vowel distribution. 5. Vowel frequency of occurrence. 6. Vowel duration system. 7. Neutral position. 8. Loss of vowel color. 9. Effect of consonant anticipation. 10. Diphthongization. 11. Vowel color and syllable type. 12. Vowel attack and release. 13. Vowel nasality. Present results are only partial, naturally, but it is hoped that even where the research is the least advanced, an understanding of the direction it is taking will benefit the language teacher.

1. ARTICULATORY DESCRIPTION OF VOWELS

The study of tongue position and of front and back cavity shape or dimensions by means of X-ray *still* photography has proved to be largely misleading. The necessity of posing may introduce gross errors – lack of naturalness, lack of realism are indicated by inconsistent tongue positions for sounds pronounced by the same subject at different intervals of time. In order to discover objectively the tongue position (or the tongue motion) that is most typical of a language for a given sound, it is necessary to observe the tongue *in motion* in the course of natural speech by means of motion picture X-ray. Moreover, it is important to place the vowels that are being compared in similar phonetic environment and prosodic conditions. With these requisits in mind we have taken motion-picture X-rays of some eight pages of comparative material of the following type. To compare English /i/ to German /i/, Spanish /i/, or French /i/, pairs of sentences like these are used: *Ein Dieb war er nie/ It's deep to his knee; La lista esta aqui/ At least it's a key; Chez qui sont partis ses habits/ McKee has a bee in his tea.* It is only from an appropriate variety of such material *in motion picture* that the characteristic vowel positions and movements can emerge. Figure 1 presents the typical /i/ vowel profiles, obtained by this method, in the four languages. Since the English /i/ is somewhat diphthongized, the tongue being in constant motion while the sound changes from [I] to [i] to [j] (see Part 10 on Diphthongization), we use here a tongue position near the end of [i], before [j] is reached. Thus, compared with French, German and Spanish /i/ vowels, English /i/ is higher at mid-tongue, less fronted at the blade (the front cavity has a typical cone shape) and slightly more retracted toward the pharyngeal wall; the jaws are more open,

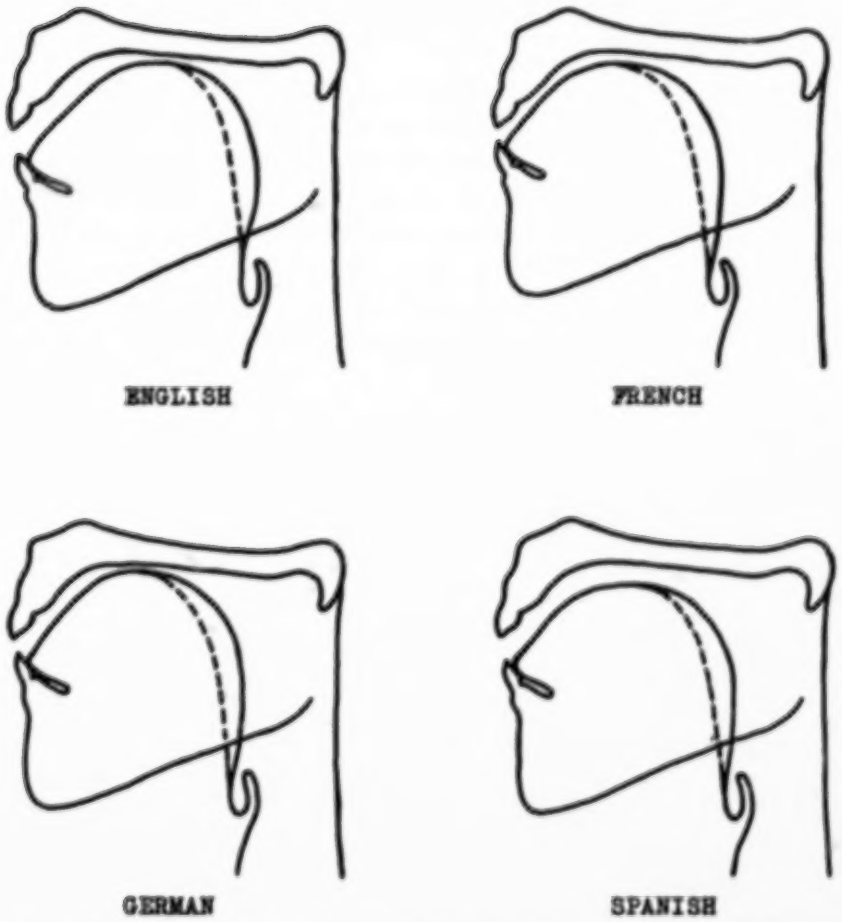

Figure 1. An example of what motion-picture X-ray can show which still X-ray cannot: the characteristic articulatory profiles of the vowel /i/ in English, German, French and Spanish, obtained by cineradiography, averaging several subjects for each language. Closure of the jaws (at the teeth) is narrower in French and German than in English and Spanish. Tongue constriction at the palate is narrower in English and German than in French and Spanish. The front cavity is characterized in English and German by a conical shape, in French and Spanish by a cylindrical shape – tongue parallel to palate. The back cavity is larger in French and German than in English and Spanish.

the lips more open and less retracted at the corners. A large front cavity and a smaller back cavity should result in a lower second formant and a higher first formant, respectively. This will be confirmed in the next chapter on the acoustic description of vowels. Differences among the three target languages can also be noted: Spanish is less close and less fronted than French – a step in the direction of [e] – but with similarity of shape. German is only less fronted, with a tendency toward the cone shape of English for the front cavity.

2. ACOUSTIC DESCRIPTION OF VOWELS

An even more objective way of comparing the vowels of languages than X-ray observation is furnished to us by recent advances in acoustic research. It consists in making "acoustic charts" of the vowels of a language directly from the sound wave of speech as it is made visible by spectrographic analysis and synthesis. Such acoustic charts can easily be understood as their shapes are remindful of the "articulatory charts" on which dots represent the highest point on the tongue profile. On the articulatory chart of Figure 2, the tongue is high-front for [i], high-back for [u], low-front for [æ], and low-back for [ɑ].

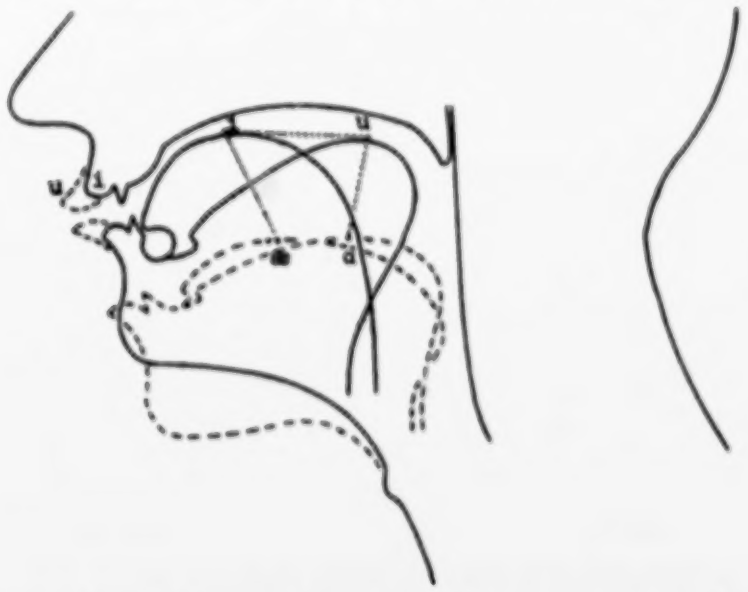

Figure 2. A reminder of the articulatory basis of the traditional vowel charts. The vowel positions on the chart correspond approximately to the highest point on the tongue-hump as seen from profile. The effects of lip rounding or spreading are not taken into account as they are in the acoustic charts (Figures 4 to 7). Figure 2 also points to what is more relevant than the highest point of the tongue in regard to actual auditory results: a) The place of constriction: at the front of the palate for /i/, at the back of the velum for /u/, at the bottom of the pharynx for the /a/ family; b) The volume and opening of the front and back cavities, which determine their natural resonance frequency: the *front* cavity is small and open for /i/, large and close for /u/, very large and very open (opposite effects) for /a/; the *back* cavity is equally very large for /i/ and /u/, and very small (below the pharyngeal tongue constriction) for /a/ – a reflection of the fact that /i/ and /u/ have the lowest, and /a/ the highest, first formants.

The acoustic chart condenses more information than the articulatory chart, because it is not limited to tongue position; it takes into account all other articulators, including, for instance, the lips, which by rounding can change [i] to [y] without moving the tongue.

Vowels are musical chords, mainly characterized by the frequency (note) of their two lowest formants, Formant 1 and Formant 2. (The only exceptions are /ɜ/ and the nasal vowels which require three formants.) The frequencies of Formants 1 and 2 are listed in Table 1 and are presented on a musical scale in Figure 3. Those formants reflect the notes of resonance of the vocal tract cavities.

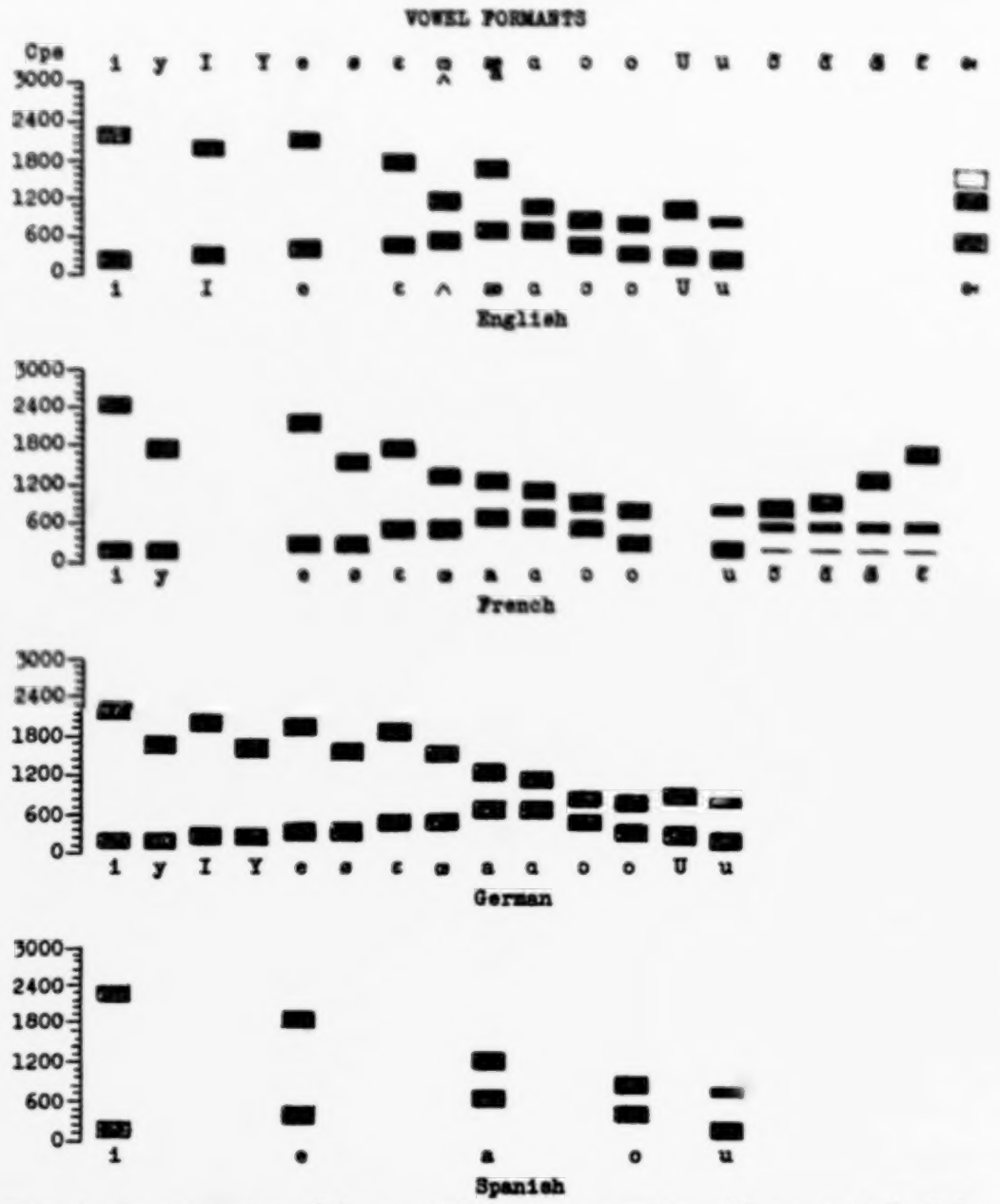

Figure 3. A presentation of the musical relation among vowel formants in English, French, German and Spanish, as they would appear on the average sound spectrograms of a male voice. These formant frequencies will produce satisfactory synthetic vowels only at a standard voice fundamental of 120 cps.

VOWEL FORMANT FREQUENCIES

Vowel	English	French	German	Spanish
/i/	2250 300	2500 250	2250 275	2300 F2 275 F1
/y/		1800 250	1750 275	
/I/	1950 350		2100 325	
/Y/			1700 325	
/e/	2100 400	2200 375	2050 375	1900 450
/ø/		1600 375	1600 375	
/ɛ/	1800 550	1800 550	1900 500	
/ɑ/,/ʌ/	1200 600	1400 550	1550 500	
/æ/,/a/	1700 750	1350 750	1250 750	1300 725
/ɑ/	1100 750	1200 750	1150 750	
/ɔ/	900 550	950 550	900 500	
/o/	800 400	750 375	850 375	900 450
/U/	1000 375		950 325	
/u/	900 300	750 250	850 275	800 275
/œ/		750 600 (250)		
/œ̃/		950 600 (250)		
/ɑ̃/		1350 600 (250)		
/ɛ̃/		1750 600 (250)		
/ɚ/	(1500)F3 1200 500			

Table 1. All vowel colors (except those of /ɚ/ and the nasals) are mainly characterized by the frequency of two formants. We give here those two frequencies in cycles per second for an average male voice with a fundamental frequency of 120 cycles per second. This fundamental will be the standard in all our comparisons. (The formants of a woman's voice may be 10 to 15 percent higher.) An additional third formant at about 1500 cps is required for /ɚ/, and an additional "nasal"

Roughly, we can think of Formant 1 as having the frequency of the back cavity (pharynx) and Formant 2 as having the frequency of the front cavity (mouth). Thus, when we measure the frequency of Formants 1 and 2 on spectrograms, it is somewhat as if we measured the resonance notes of the back and front cavities. Obviously the shape and size of those two cavities are different for each vowel, and as a result the musical chords are also different.

All charts in Figures 4, 5, 6 are *acoustic* charts obtained by plotting the frequencies of Formants 1 and 2 in abscissa and ordinate. For instance, [i] is to the

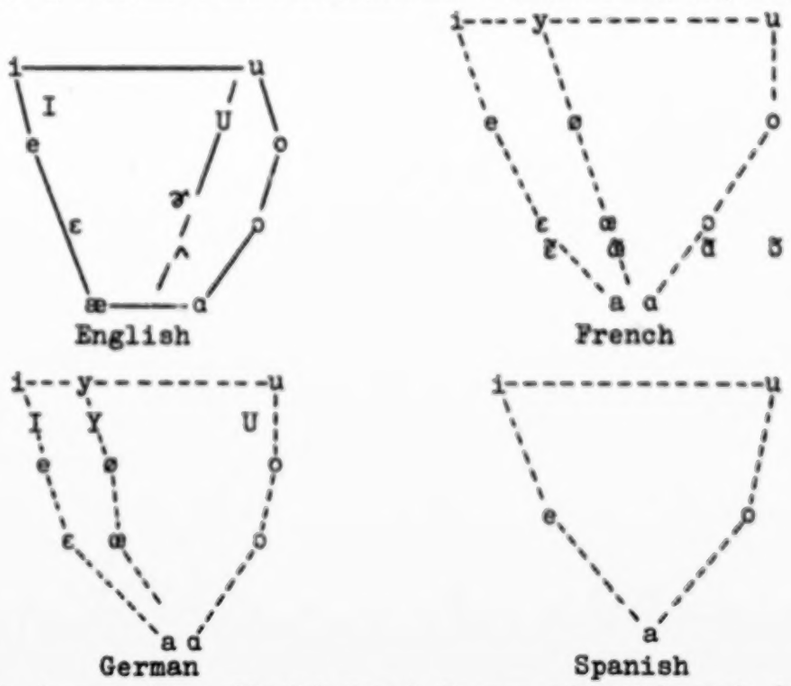

Figure 4. Acoustic charts of English, French, German and Spanish vowels obtained by coordinating the formant frequencies of Figure 3: Formant 1 in ordinate and Formant 2 in abscissa. Such charts reflect not only the elevation of the tongue (see Figure 2) but the whole vocal tract resonance system, which depends on cavity volume and opening. The factors of lip rounding and tongue constriction are therefore taken into account, as well as those of tongue lowering and fronting. (See text for eleven points of comparison, among the four languages, based on these acoustic charts.) Reading these charts, one realizes, for instance, that for the French nasal /ɔ̃/ the first formant is somewhat higher than for /ɔ/ and the second formant much lower than for /ɔ/, about as low as for /o/ or /u/. In articulatory terms, it means a back cavity nearly like that of /ɔ/ and a front cavity nearly like that of /o/. X-rays confirm this. For the nasal /ᾱ/, the first and second formants are closer to those of /ɔ/ than to those of /ɑ/. Anyone can experience this by trying to denasalize an /ᾱ/.

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formant at about 250 cps contributes to nasality. The low formants of nasal vowels, at 600 cps and 250 cps, have very low intensity (about 12 decibels down).

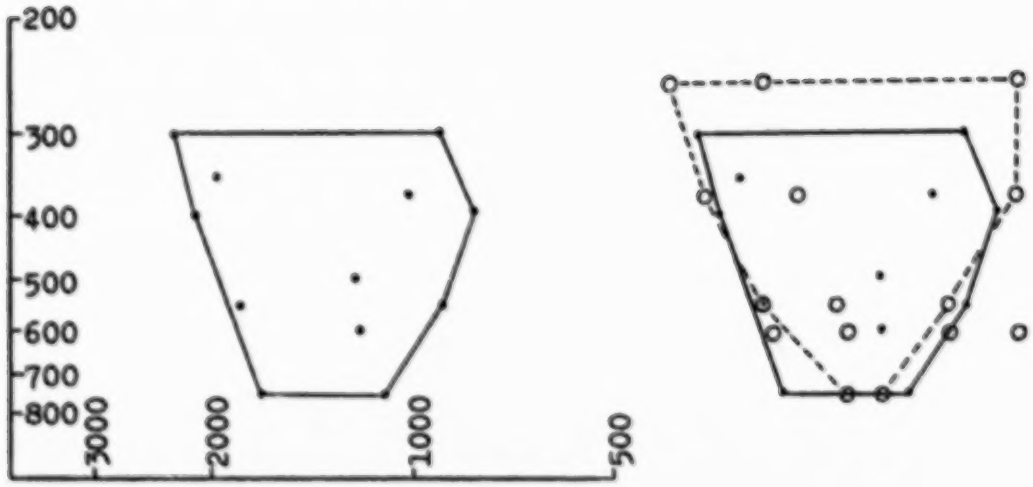
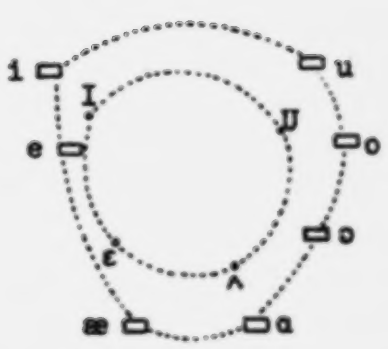


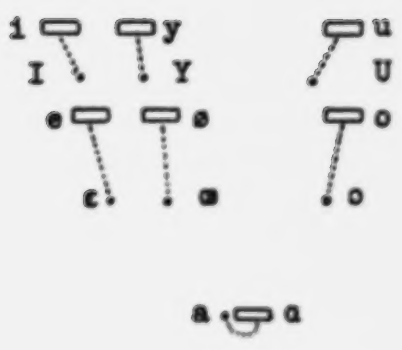
Figure 5. To facilitate comparison between English vowels and those of French, German or Spanish, the English chart shape is superimposed over the other three.

left and high on the charts because it has a very low frequency in Formant 1 and a very high frequency in Formant 2. In articulatory terms this means that [i] has a very large cavity in back and a very small cavity with spread-lip opening in front (see Figure 2). If the opening of the front cavity were closer because of lip rounding, as for [y], the note of Formant 2 would be lower – less toward the left on the chart.



English

French



German

Spanish

Figure 6. Differences in the duration systems are emphasized. For stressed positions, in English the shorter vowels are more central; in German they are more open; in French and Spanish distinctive differences of duration are not stable. (For details, see paragraph 6 in this chapter, and Chapter 6 on Vowel Duration Systems.)

Methods of frequency measurement for all vowels. Linguists from many countries have attempted to measure Formants 1 and 2 on spectrograms and have published their results. When we verify those results by synthesis, they do not stand the test, either because of technical faults in measuring or because of variations due to human elements not entirely explained – the formants of a woman can be about 15 per cent higher than those of a man with the same dialect, and even persons of the same sex can show considerable divergence of formant frequencies for a similar sound.

The frequency *ratio* among formants by different persons is fairly constant, however, so that spectrographic analysis can be used with confidence to obtain the *relative* values of formant frequencies. For instance, the second formant is always lower for [y] than for [i], regardless of the speaker's sex or age. But in order to compare the vowels of different languages, *absolute* values according to a *uniform standard* were needed.

This problem was solved by using synthetic (artificial) vowels made on our speech synthesizer at a uniform fundamental frequency of 120 cycles per second, which is a good standard of fundamental frequency since it corresponds to a typical average male voice. Formant frequencies of synthetic vowels produced from hand-painted spectrograms were varied, and the resulting vowels were tested by natives of each language, and by linguists, until found typical. Thus the values obtained for Formants 1 and 2 of all vowels on Figures 3 to 7 are comparable among themselves and comparable from one language to another – with the understanding that they are valid for a male voice speaking at a fundamental frequency of 120 cps.

Moreover, the frequencies of all vowels on Figures 3 to 7 are the most characteristic *single* frequencies, those by which a vowel is best identified by natives, in the absence, or regardless, of diphthongization.

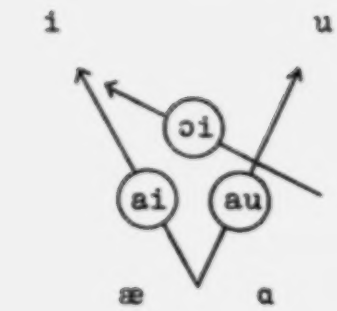
Even though our vowel charts have been obtained by acoustic measurements, we may use the articulatory terminology every one is used to in discussing them.

Let us now use Figures 4, 5, 6, and 7 to compare the English vowels to those of the three target languages, first as a whole, then individually. ("English" will always mean "American English.")

1. The vocalic system of English is rich and complex: a minimum of 12 monophthongs contrasting among themselves by color (formant frequencies) and by length (Figures 4, 5, 6), and 3 diphthongs (Figure 7). It is much richer than Spanish: 5 monophthongs and 4 main diphthongs, and only slightly less so than German: 14 monophthongs and 3 diphthongs; or French: 15 monophthongs and no diphthongs. (The problem of whether the two mid-series [e, ø, o ,] [ɛ, œ, ɔ] represent 3 or 6 phonemes in French is unsolved. They are in complementary distribution in some series: *nez-mette, peut-peuvent, mot-mort,* which have a high return, but they are in contrast in others: *pré-prêt, jeûne-jeune, paume-pomme,* which have a low return.)

2. The vocalic system of English is *more open* (low) than those of the three target languages. Its close vowels are less close. Its center of gravity is lower. And its low vowels are more extreme (close to cardinal vowels) than its high vowels, which is not the case with the target languages.

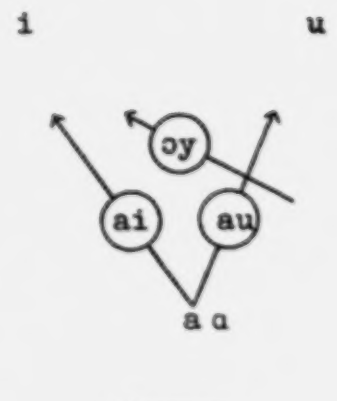
3. If we call "back" vowels all those that are clearly to the right of center on the acoustic charts, the vocalic system of English appears as richer in *back* vowels than the three target languages. Figure 4 shows that English has two back and one front series; in French and German the proportion is inverse: two front and one back series; and in Spanish the front and back vowels are in equal ratio.



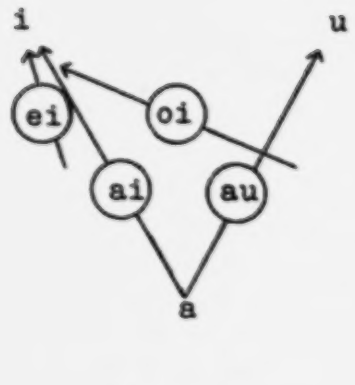
English

None

French



German



Spanish

Figure 7. The main decreasing diphthongs of English, German and Spanish (there are no decreasing diphthongs in French) are presented in relation to the acoustic charts of Figure 4. Comparisons of the actual articulatory travel and acoustic change of the formants, as well as the decrease of intensity, are being investigated. (See Chapter 10, A).

4. The vocalic system of English is *less rounded* than those of the three target languages. Not only is the ratio of rounded vowels smaller (1/3 in English, 1/2 in Spanish, 2/3 in French, 2/3 in German), but those vowels which use lip rounding in English, such as /u, o, ɔ/, have the rounding less pronounced than corresponding vowels in French, German, and Spanish.

Indeed, one of the most characteristic features of English is its somewhat back and unrounded series of vowels /ʌ, ɝ, U/ and perhaps even /u/. None of the three target languages possesses such a series.

5. High-close and high-open vowels /i, I, u, U/ are *less extreme* (not so near the outside on the acoustic charts) in English than in the three target languages. The

greatest difference is with French in /i, u/, but it is also noticeable with German in /i, I, u, U/, and with Spanish in /i, u/. In other words, the high-close and high-open vowels of English tend slightly toward center, unlike the corresponding vowels in French, German and Spanish.

On the other hand, low vowels like /æ/, /ɑ/ are more extreme (more peripheral on the acoustic charts) in English than in the target languages.

"Centering" further appears as a distinguishing characteristic of English if we note that about 90 percent of unstressed vowels turn to some sort of schwa (neutral vowel) and are located inside the inner circle of the English chart of Figure 6. Since unstressed vowels comprise about 61 per cent of all English vowels in connected speech, the proportion of vowels located in this inner circle is over 50 per cent. The proportion of centered vowels is very much smaller in the three target languages. (The effect of unstressing on vowel color is the subject of another chapter.)

6. In the English system, vowel duration plays a distinctive role. Four vowels, / I, U, ɛ, ʌ/, are shorter than the others, on the average; and those shorter vowels are all nearer the center of the vowel chart. As shown by the two dotted-line circles in Figure 6, the longer vowels are located on a larger peripheral circle; the shorter ones on a more central circle. Briefly stated, in English, vowel shortening correlates with vowel centering, for stressed as well as for unstressed vowels. (Historically, shortening preceded centering and may be assumed to have caused it.) In German, where differences of length are more pronounced than in English, the correlation is somewhat different: a) long and short vowels go in pairs; b) except for short /a/, the shorter vowels are more open and slightly more centered than the corresponding long ones. In Spanish and French, duration has no stable contrastive function. (The subject of vowel duration is treated in another chapter.)

7. In most American-English dialects, all vowels are more or less diphthongized. This diphthongization plays an important role in distinguishing vowels that seem too close on the chart. For instance /I/ diphthongizes toward /ə/. This helps in distinguishing it from /e/ which diphthongizes toward /i/. The three target languages do not noticeably diphthongize, not even German in its long /e/ and /o/. (Diphthongization is the subject of a special chapter.)

8. Let us summarize the phonetic characteristics of each vowel system. Comparatively, English vowels are predominantly low, back, unrounded, with a strong tendency to center the short and unstressed (except when very low). Duration contributes to vowel distinctions. All English vowels are more or less diphthongized. Most characteristic series: the somewhat back-unrounded /u, U, ɚ, ʌ/.

9. Comparatively, French vowels are predominantly high, fronted, rounded, and extreme (except when low). The /i, e, y, ø, u, o/ are nearly cardinal. The open / close difference in the mid-vowels is very pronounced. Duration is negli-

gible in vowel distinction. There is no diphthongization. Most characteristic series: the front-rounded /y, ø, œ/ and the nasals /ɛ̃, œ̃, ɑ̃, ɔ̃/.

10. Comparatively, German vowels are predominantly high, fronted, rounded, more extreme than English but less than French. Differences of duration play an important role in vowel distinction (more than in English). For every long vowel except /ɑ/ there is a corresponding short one which is more open. There is no diphthongization, not even in long, close /e/ and long, close /o/. Most characteristic series: the front rounded /y, Y, ø, œ/, which is different from the French series in that it offers four degrees of opening within a small range; French offers three degrees within a larger range. Differences of duration help in distinguishing vowels that may be somewhat close on the vowel chart, such as /y/ from /Y/, or /Y/ from /ø/.

We are aware that long, open /ɛ/ exists as a phoneme for some speakers of North German. It is not included on our vowel charts on the ground that a majority of speakers, and of our informants, tend to assimilate it to the long, close /e/ phoneme.

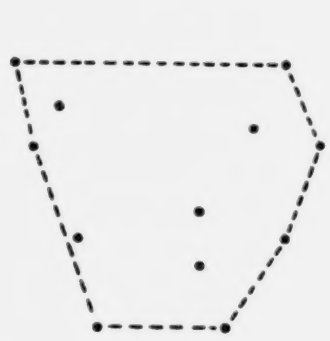
11. Comparatively, Spanish vowels are predominantly high and peripheral. They are distant from each other. The open/close difference of mid-vowels is negligible. Differences of duration are not distinctive. There is no diphthongization. Most characteristic series: the mid-open/mid-close vowels /e/ and /o/, which are midway between the French or English close and open vowels.

3. NEW VOWEL SOUNDS

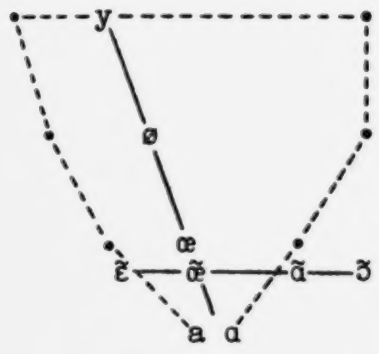
We shall consider here the vowel phonemes that are radically different from those of another vowel system (see Figure 8).

1. An American learning French has to meet three new sets of vowels in the following order of difficulty: a) The three front-rounded vowels /y/, /ø/, /œ/. Since he is used to combining rounding with tongue-backing, he has to acquire the very new habit of rounding while *fronting* his tongue: u/y, o/ø, ɔ/œ: *sous/su, sot/ceux, sol/seul.* b) The two low *a* sounds, which are very close to each other and located between the two American low sounds on the acoustic chart. The /ɑ/ has a much lower frequency of occurrence than the /a/ (about 150 lexical words vs 6000), but minimal pairs such as *tache/tâche, patte/pâte* are still alive in Paris. c) The four nasal vowels: /ɛ̃/, /œ̃/, /ɑ̃/, /ɔ̃/. Note on Figure 8 that acoustic analysis has clearly demonstrated that those nasal vowels do not have the same place of articulation as their (supposedly) oral counterparts.

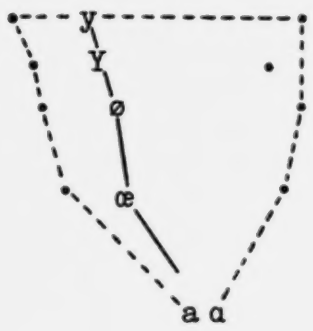
2. An American learning German has to face two new groups of vowels: a) The four front-rounded vowels, long /y/, short /Y/, long /ø/, short /œ/. As in French, he has to learn to combine lip-rounding with tongue-fronting, not with tongue-backing: u/y, U/Y, o/ø, ɔ/œ: *Kuhle/kühle, Hutte/Hütte, Boden/Böden, Holle/Hölle.* These vowels should be more difficult to distinguish than the



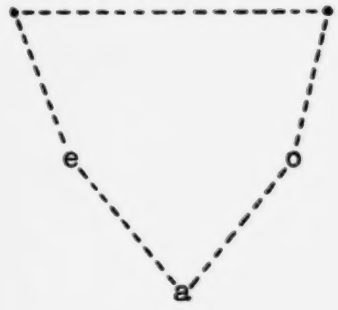
English



French



German



Spanish

Figure 8. All phonetic symbols indicate vowels that are radically new for an American student learning either French, German, or Spanish. These new vowels number nine for French, six for German, and three for Spanish. (See text for details.)

French ones since there are four of them in less articulatory space than for three in French. However, as mentioned above, their distinction is considerably aided by the long/short distinction, which is much more marked in German than in English. b) The two *a* sounds, which are farther back than the French ones, but not so far back as the American /ɑ/. (Phonemic symbols have a different value in each language, of course.)

3. An American learning Spanish has to face three new vowels that are midway between pairs of coresponding American vowels: a) A pair of vowels (symbols: /e/, /o/) that are less close than American /e/, /o/ and less open than American /ɛ/, /ɔ/. b) An /a/ that is clearly less fronted than American /æ/ and less backed than American /ɑ/.

Summary of new vowel sounds for an American

In French:	y ø œ, a ɑ, ɛ̃ œ̃ ɑ̃ ɔ̃
In German:	y Y ø œ, a ɑ
In Spanish:	e o a

4. VOWEL DISTRIBUTION

It is important for a language teacher to know in which positions vowels occur in the target language as well as in the native language of the students. As a start toward complete pictures of positional and allophonic distribution, Tables 2, 3, 4 and 5 present, in examples, the positional distribution of *stressed* vowels and the schwa in English, German, French and Spanish.

English Stressed Vowels

	Initial	Medial	Final
i	eel	seen	see
I	if	sit	
e	ate	bait	day
ɛ	ebb	sell	
æ	at	cat	
ɑ	are	clock	blah
ɔ	ought	thought	saw
o	own	note	no
U		book	
u	ooze	boot	two
ʌ	up	sun	
ɝ	earth	first	fur
ai	ice	time	pie
au	out	down	cow
ɔi	oil	boil	boy
(ə	above	believe	sofa)

Table 2. The positional distribution of English vowels in words shows mainly that short vowels /I/, /ɛ/, /U/, /ʌ/, and the vowel /æ/, which is short in British English, do not occur in final position.

In American English, (Table 2), the short vowels do not occur in final *stressed* position. Neither does the /æ/, which is not a short vowel in American English but is in British English. In addition, the short /U/ does not occur initially.

In German, (Table 3), as in English, the short vowels do not occur in final *stressed* position.

German Stressed Vowels

	Initial	Medial	Final
a	Aale	Kahn	da
a	alle	kann	
e	Ehre	Segen	See
ɛ	Ernte	Säcke	
i	ihn	bieten	wie
I	in	bitten	
o	Ofen	Sohn	so
ɔ	offen	Sonne	
u	Uhrzeit	Ruhm	Kuh
U	Unzeit	Rum	
ø	Öfen	Höhle	Bö
œ	öffnen	Hölle	
y	Üben	Mühle	früh
Y	üppig	Müller	
ai	Eimer	nein	zwei
au	auch	Raum	schlau
ɔy	Europa	neun	neu
(ə		arbeitet	eine)

Table 3. The positional distribution of German vowels in words shows mainly that short vowels do not occur in final position.

In French, (Table 4), the tendency is clearly for mid-close vowels not to occur medially and for mid-open vowels not to occur finally, in accordance with the Law of Position ("in an open syllable mid-vowels are close: *mes, meut, mot* [me, mø, mo]; in a closed syllable mid-vowels are open: *mère, meurt, mort* [mɛr, mœr, mɔr]"). But the influences of spelling or etymology have created a few exceptions, so that in fact, of the mid-close vowels, only [e] never occurs medially — [o] and [ø] occur medially in a few hundred words, mainly of the types *pauvre* [po:m], *pose* [po:z], *jeûne* [ʒø:n], *creuse* [krø:z], with concomitant extra length; and of the mid-open vowels, only [ɔ] and [œ] never occur finally — [ɛ] occurs finally in the dialect of nearly one-third of northern French speakers, mainly in words of the types *prêt* [prɛ] and *j'allais* [ʒalɛ]. (Southern France observes the Law of Position without exception. But in the unaffected speech of the most cultivated class, [prɛ], [ʒalɛ] is not only the pronunciation of all southern speakers but also that of a majority of northern French speakers.)

Spanish shows all vowels in all three positions except for the diphthong /ei/ which does not occur initially.

Summary: The missing positions are related, in German and English to the short/long differences, in French to the Law of Position.

French Stressed Vowels

	Initial	Medial	Final
i	île	mille	lit
e	et		pré
ɛ	elle	belle	(prêt)+
a	acte	patte	là
ɑ	âme	pâte	las
o	haut	(paume)	dos
ɔ	homme	pomme	
u	outre	foule	tout
y	une	mule	vu
ø	eux	(jeûne)	deux
œ	heure	jeune	
ɛ̃	Inde	quinze	pain
ɑ̃	humble	lundi	parfum
ɛ̃	anse	sens	cent
ɔ̃	onze	bombe	son
(ə		premier	)

+ Those in parenthesis are unstable or of very low frequency.

Table 4. The positional distribution of French vowels in words shows a tendency for mid-close vowels /e/, /o/, /ø/ not to occur in closed syllables, and for mid-open vowels /ɛ/, /ɔ/, /œ/ not to occur in open syllables.

Spanish Stressed Vowels

	Initial	Medial	Final
i	ir	fin	df
e	el	ver	fe
a	has	tan	da
o	hoz	dos	no
u	un	luz	td
au	auto	causa	jau
ei		reina	ley
ai	aire	baile	fray
oi	oiga	lloica	doy

Table 5. The positional distribution of Spanish vowels in words shows that nearly all vowels occur in all three positions.

The schwa vowel [ə] behaves differently in each of the four languages. It occurs in three positions in English, two in German, one in French, and does not occur in Spanish, where natives use an [e] sound to mark their hesitation.

5. VOWEL FREQUENCY

Frequency of occurrence of vowel phonemes is a good indication of the auditory impression a foreigner receives of a language when he enters the country in which it is spoken. This impression should be recreated for the new student of a target language with the help of appropriate material in which the sounds would be balanced according to frequency of occurrence. The first learning sequences should also take into account such frequency of occurrence.

Table 6 presents a preliminary comparison of vowel phoneme frequency based on short samplings of combined narrative and spoken material. (This will be done on a large scale later.)

Stressed and unstressed vowels are not separated in this table. In German, any vowel can occur in stressed as well as in unstressed position except /ə/, which is always unstressed. In the three other languages all vowels can occur stressed as well as unstressed. (Loss of vowel color under lack of stress is mentioned in another chapter.)

German frequency of occurrence has much in common with English. Both have /ə/ as their most frequent vowel. (However, in German /ə/ is always unstressed, whereas in English it occurs as stressed in a proportion of approximately 1 to 8: one [ʌ] to eight [ə] sounds.) Furthermore, the five most frequent vowels are /ə, I, æ, ɛ, e/ in English, and /ə, a, e, I, ɛ/ in German. The three diphthongs have rather low frequency in both languages and their frequency order is the same: /ai/, /au/, /ɔi/. We find this to be even more true in Spanish, where the four diphthongs /ei/, /ai/, /au/, /ɔi/ occupy the last four positions on the frequency list.

German and French have in common the front-rounded series, the [y], [ø] family, which have no equivalent in English nor in Spanish. However, in both French and German, those front-rounded vowels have a very low frequency of occurrence. They serve therefore much less than is generally assumed in characterizing the auditory impression of those languages, and should not be taught too early.

The same thing must be said of the French nasal vowels. They have a much lower frequency of occurrence than the corresponding oral vowels: /ɑ̃/ is lower than /a/ and /ɑ/, /ɛ̃/ than /e/ and /ɛ/, /ɔ̃/than /o/ and /ɔ/, /œ̃/ than /ø/ and /œ/. They also have a lower frequency than the oral vowels from which they mainly came: /a/, /e/, /ɛ/ for /ɑ̃/; /i/ for /ɛ̃/; /y/ for /œ̃/; and /u/, /o/, /ɔ/ for /ɔ̃/. (Denasalization toward the end of the Middle Ages can account for this low frequency of nasals.) On the basis of the low frequency of occurrence of

Comparative Frequency of Occurence of Phonemes

English		Prench		German		Spanish	
Vowel	%	Vowel	%	Vowel	%	Vowel	%
ə	22.99	ə	19.29	ə	23.88	e	32.80
ɪ	14.44	a	16.69	ɪ	11.52	a	30.38
ɜ	9.44	i	12.39	a	10.72	o	21.56
i	8.49	e	7.60	ai	7.88	i	10.48
a	6.99	ɑ̃	7.59	ɛ	7.08	u	4.23
ɛ	6.85	ɛ	6.69	e	6.73	ei	0.20
u	5.60	u	6.40	i	5.88	ai	0.15
ai	5.50	o	5.05	ʊ	5.28	au	0.15
o	4.95	y	4.70	ɑ	3.89	oi	0.05
ʊ	4.40	ɔ̃	3.85	u	3.84		
e	3.95	o	2.60	ɔ	3.74		
au	2.20	ɛ̃	2.45	au	3.14		
ɔ	2.00	œ̃	1.80	o	2.29		
ʊ	2.00	ø	1.70	y	1.30		
oi	0.20	œ	1.05	Y	0.98		
		ɑ	0.15	ø	0.95		
				œy	0.55		
				œ	0.35		
	100.00		100.00		100.00		100.00

Table 6. Frequency of occurrence of vowel phonemes shows similarity on the one hand between German and English, and on the other between Spanish and French. It also reveals that the most characteristic vowels of French and German, such as the nasals or the front-rounded, have low frequency of occurrence, and that diphthongs in English, German and Spanish have lower frequency of occurrence than monophthongs.

French nasal vowels, French is a more *oral* language than appears on the surface, and the nasals should be taught late in the period of conditioning to new sounds.

Spanish and French have in common a high proportion of fronted vowels. They share their first two vowels: /e/ and /a/ have the highest frequency of occurrence in both languages.

Finally, Spanish and French also have in common a high proportion of vowels (against consonants): 43.6% and 43.2%, as opposed to 37.4% and 36.3% in English and German, respectively.

6. *VOWEL DURATION SYSTEMS*

Variations in vowel duration can be distinctive (contribute to change of meaning) or non-distinctive. In English, the difference of duration between *bit* and *beat,* in a ratio of nearly 2 to 3, about 10 centiseconds and 14 centiseconds in equally stressed positions, is distinctive. It has to be *learned* when learning English, and one easily becomes conscious of it. But the differences between *bit* (10 cs) and *bill* (14 cs), *bit* and *bid* (16 cs), *bit* and *bin* (18 cs), are non-distinctive and made unconsciously. They are *conditioned* by the force of articulation of the following consonant. German and French also have both learned (distinctive) and conditioned (non-distinctive) variations in vowel length, but Spanish only has conditioned ones. Let us consider the two types separately.

A. Distinctive vowel length

a) The importance of *distinctive* vowel length is greatest in German, then in English, then in French.

b) In stressed position the ratio of short vowel to long vowel counterpart is nearly

2 to 5 in German	bitte / biete
2 to 3 in English	bit / beat
3 to 4 in French	mettre / maitre

c) In German the role of duration in the i/I type distinction is considerable in stressed position. It is perhaps greater than the difference in color. In English the role of duration in the i/I type distinction is certain but not considerable. It is probably smaller than the difference in color. In French the role of duration in the ɛ/e: type distinction *(mettre/maitre)* is strong *when the difference of duration is observed.*

d) In German and English, this difference of length in stressed position is in a constant ratio and is always observed. In French it is in an unstable ratio and is made irregularly. It is observed only in careful diction and by a minority of speakers.

e) In German, the distinctive difference of vowel duration in stressed position applied to seven pairs of vowels: i/I, y/Y, u/U, e/ɛ, ø/œ, o/ɔ, ɑ/a. (Refer to Figure 6) For every long vowel there is a corresponding short one. Duration differences are integrated in the system of vowel phonemes. In American English, distinctive duration is much less integrated in the system. There are three pairs in which duration plays some distinctive role: i/I, u/U, e/ɛ; but there is no one-to-one correspondence among the long and the short as a whole. It is perhaps more realistic to say that seven vowels are longer: /i, u, e, o, æ, ɑ, ɔ/,

and that four are shorter: /I, U, ɛ, ʌ/. (The diphthongs are long, naturally, both in German and in English.)

In French the learned distinction short/long applies to two pairs of vowels, but, as we said, it is very unstable. The pairs are:

ɛ/e:	mettre/maitre, tette/tête, etc.
a/ɑ:	tache/tâche, patte/pâte, etc.

Because of the instability of these duration differences, it is often said that duration is not distinctive in French. In two other types of pairs, a difference of duration is made regularly, but it seems to be conditioned rather than learned. These types include six pairs of vowels:

ɔ/o:	pomme/paume	open and close vowels in closed syllable
œ/ø:	jeune/jeûne	
ɛ/ɛ̄:	messe/mince	
ɔ/ɔ̃:	mode/monde	oral and nasal vowels in closed syllable
a/ā:	bac/banque	
œ/œ̃:	au meuble/homme humble	

f) Note. The assumption that, in English, shortening tends to center a vowel is confirmed by the great number of vowels that turned to schwa, under the influence of Celtic substratum, when unstressed and short. Compare *politic* and *political:* [pɑlətIks], [pəlItəkəl].

B. Non-distinctive vowel length

The length of vowels can also vary under the influence of a great many physiological factors. Some are found in the vowels themselves: diphthongs are on the average longer than monophthongs; open vowels are longer than closed ones (this has been observed in English, German, and Spanish); nasal vowels are longer than oral ones (this has been observed in French). Other factors are found in the contiguous sounds, mainly the following consonant: vowels are longer before lenis than before fortis consonants; before voiced than before voiceless consonants; before fricative than before plosive consonants; before nasal stops than before oral stops, etc. These conditioners of vowel duration seem to operate somewhat similarly in all languages, but further investigation will be made.

Table 7 shows typical variations of vowel duration under all influences that have been investigated in English. Only one of those factors is learned: abridging/expanding (left, vertically); all the others are physiological conditioners: close vowel/open vowel, monophthong/diphthong, voiced/voiceless, stop/fricative, liquid/solid, and oral/nasal. These factors combine to vary the vowel length in a ratio of 1 to 4. This ratio would appear, for instance, in the vowels of: *fit* (10 cs), *five* (40 cs).

Comparable tables will be made for the other languages.

Table 7. THE FACTORS OF VOWEL LENGTH IN ENGLISH. Numbers are in centiseconds and apply to stressed syllables. Example of minimal and maximal length: *fit* (10 centiseconds, an abridged close monophthong before a voiceless stop consonant; *fize* (40 centiseconds, an expanded diphthong before a voiced

		Voiceless		Voiced			
		Stop	Fricative	Liquid	Solid		
					Stop		Fricative
					Oral	Nasal	
		Fr⟷Bk	Fr⟷Bk	Fr⟷Bk	Fr⟷Bk	Fr⟷Bk	Fr⟷Bk
	Before⟶	p t k	f θ s ʃ	l r	b d g	m n ŋ	v ð z ʒ
Abr. Close Mono.	I-U	10	12	14	16	18	20
Abr. Mid Mono.	ɛ-ʌ	12	15	17	19	21	24
Exp. Close Mono.	i-u	14	17	20	22	25	28
Exp. Mid Mono.	e-o	16	19	23	26	29	32
Exp. Open Mono.	æ-ɑ-ɔ	18	22	26	30	33	36
Exp. Diph.	ai-au-ɔi	20	24	28	32	36	40

7. THE NEUTRAL VOWEL POSITION

This is in principle the vowel one utters when hesitating, when looking for the right word or the next thought. It can also be the average vowel of the weakest stressed syllables, or the implicit vowel toward which all vowels move under unstress. If it is different in each of our four languages, it should be indicative of the center, or basis, of articulation. X-rays and spectrograms are being studied for this sort of comparison.

At present, the point of articulation of the neutral vowel appears to be most fronted in Spanish and most backed in English; its lip rounding most pronounced in French and least pronounced in Spanish; its degree of opening greatest in English and smallest in Spanish. We might tentatively say that the English neutral vowel is somewhat back, lower than mid, and rather unrounded. The German neutral vowel is fairly fronted, mid-open, and between rounded and spread, a little closer to the former. The French neutral vowel is fairly fronted, somewhat higher than mid-open, and rounded. The Spanish neutral vowel is fairly fronted, fairly spread, and between mid-open and mid-close.

It is important to teach this key position at an early stage in the conditioning period.

8. LOSS OF VOWEL COLOR

It seems that in all languages, vowels fail to retain the same timbre when the stress is weak as when it is strong. As a first step toward the comparison of the influence of stress upon vowel color, we are studying by spectrographic analysis the corresponding vowels of such pairs as: ab*o*lish/ab*o*lition, exp*e*cting/exp*e*ctation, exh*i*bit/exh*i*bition, in s*u*bstance/ins*u*bstantial; M*ö*bel/m*ö*bliert, fat*a*l/Fat*a*lismus, M*u*siker /M*u*sik; oc*u*pan/ oc*u*paban, agr*a*dan/ agr*a*daban, ach*i*can/ach*i*caban; fat*i*gue/fat*i*gant, ét*u*de/ét*u*die, prov*o*que/prov*o*quer.

We are interested in finding a) how much change takes place in terms of formant frequency, b) what is the direction of the change – front, back, center, periphery – in each one of the four languages. The articulatory aspect of this change of timbre will also be investigated on motion-picture X-rays.

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fricative). To the left are the internal factors (in the vowel itself): abridging vs expanding, close vs open, monophthong vs diphthong. Above are the external factors (in the articulatory force of the following consonant): voiceless vs voiced, stop vs fricative, liquid vs solid (all voiced consonants except /r/, /l/), oral vs nasal, more fronted vs less fronted. All factors are automatic, physiological – and therefore non-distinctive – except abridging vs expanding, which is learned and therefore distinctive to the extent that it contributes to such phonemic contrasts as *bit/beet, bet/bate, full/fool, cup/cop.*

9. CONSONANT ANTICIPATION

The articulation of a vowel is affected by the anticipation of the following consonant in all languages, but to a very different degree depending on the language. The behavior in the anticipation of post-vocalic consonants and its effects on vowel color, vowel length and syllabic aspect are being studied by cineradiography and spectrography for the comparison of English to Spanish, German and French. The articulatory organs that best permit the observation of anticipation are the lips, the jaws, the tongue tip and the velum. For anticipation of laterals, for instance, the tongue tip is being observed in comparative sentences such as, for English and German: *Louis calculated to film the float in the canal / Ludwig kalkulierte, die Flotte im Kanal zu filmen.* Distortion of vowel color by consonant anticipation appears to be much more pronounced in English than in the other languages under study.

10. DIPHTHONGIZATION

For the sake of convenience, let us call *diphthongs* the vowels in which a particular change of color is necessary for comprehension: American English *fire* [fair], *shout* [ʃaut], *joy* [dʒɔi] would generally be understood as *far* [fa:r], *shot* [ʃa:t], *jaw* [dʒɔ:] without the change of color. And let us call *diphthongized vowels* the vowels in which no particular change of color is indispensable for comprehension: American English *bait, boat, bat, bit, beet, boot* are not much more likely to be confused with other words when they are pronounced [be:t], [bo:t], [bæ:t], [bIt], [bi:t], [bu:t] than [bɛeit], [bɔout], [bɛæət], [bIət], [bIijt], [bəUuwt].

English possesses diphthongs and diphthongizes its monophthongs. German and Spanish possess diphthongs but do not noticeably diphthongize their monophthongs. Modern French does not possess diphthongs, nor does it diphthongize its monophthongs. Let us treat diphthongs and diphthongization separately.

A. *Diphthongs.* English, Spanish and German have three diphthongs of the same type: [ai], [au], and [oi], in very broad transcription. This coincidence offers an opportunity for comparing diphthongs among the three languages by cineradiography and spectrography. Comparative sentences of the following type are being used: *It's noise in my finest house / In Neuss ist mein feines Haus.* Diphthongs seem to differ in three aspects: a) in the color of initial and final target vowels; b) in the relative amount of steady state; c) in the decrease of intensity from beginning to end.

B. *Diphthongized vowels.* For the acoustic study of diphthongization, a thorough knowledge of spectrography is necessary in order not to confuse formant changes that relate to the perception of diphthongization with formant changes (formant "transitions") that relate to the perception of adjacent consonants. Spectrographic synthesis provides a dependable protection against such causes of error. The use of an electronic time-gate also permits ascertaining which

portion of a syllable belongs to the vowel and which to the consonant (or consonants) by perceptual test of separated portions.

For the articulatory study of diphthongization, cineradiography synchronized with sound is an excellent tool. However, a *number* of subjects must be filmed to find what feature is common to most speakers of a given language. Comparative sentences of the following types are being used: for English and Spanish /e/: *It's a day still to face/Que le dé dos cafés;* for English and German /e/: *In vain they work every day/Für wen gibt es keinen Tee;* for English and French /e/: *The day before pay wasn't gay/Céder à l'épée n'est pas gai.*

A detailed acoustic and articulatory comparison of the vowel types [o], [e], [u], [i] in English and French was completed in our research laboratory and published in *The French Review* (Vol. 37, pp. 64–76, Oct. 1963). Its figures present the comparison of those four vowels under five aspects: a) the closest phonetic transcription of the articulatory sequences of the English/French contrasts: *know/nos; Fay/(le)ver; do/doux; bee/(ha)bit;* b) the profile view sequences of the lips taken at 24 frames per second; c) the front view sequences of the lips at 24 frames per second; d) the X-ray profile sequences of the tongue at 24 frames per second; e) the sound tracks of the eight sequences. The closest transcriptions, on the basis of frame by frame analysis, spectrograms, and auditory study turned out to be: for English *know* [nnnɔɔɔɔoow], for French *nos* [nnnooooo]; for English *Fay* [fffɛɛɛɛɛeeeej], for French *ver* [vvveeeee]; for English *do* [dddəUUUuuuuw], for French *doux* [ddduuuuu]; for English *bee* [bbbIIiiij], for French *bit* [bbbiiii].

The general comparison can be summarized under three aspects. 1. The English vowel is articulated in a constant movement; it changes from frame to frame. The French vowel shows sequences of several frames in nearly complete stability. 2. The English vowel reaches its goal indirectly by way of a wide detour. It starts by rapid over-opening of lips, tongue and jaws (the latter moving late in the initial phase), followed by slow closing and finally over-closing. The /o/ is especially interesting to observe. The tongue constriction displaces itself in a semi-circular movement: it starts in the lower pharynx, rises along the back wall of the pharynx and turns forward toward the velum to end in the front portion of it as for English /u/ but with a narrowness of the pharyngeal cavity that corresponds more nearly to English /w/. The French vowel, on the contrary, reaches its goal directly, without detour, and does not overshoot the mark in the last stage. 3. Energy distribution, as seen on the sound track, is also very different. The English vowel is essentially decreasing, its maximum of intensity being regularly near the beginning. The French vowel does not show any noticeable decrease of intensity; in some cases it even shows an increase.

Observing the progression of the tongue construction along the walls of the palate, velum and pharynx on these X-ray sequences is indeed indicative of the vowel color changes that occur. But even more interesting and more closely related to the changes of vowel color are the front and back cavity sizes and openings and their comparison among languages.

11. VOWEL COLOR AND SYLLABLE TYPE

The effect of the type of syllable (closed or open) on the color of vowels seems to be different in each language. It is very marked in French where mid-vowels tend to be open when checked and close when free: *j'aime* [ʒɛm], *j'ai* [ʒe], *respire* [rɛs], *répit* [re]. But it is perhaps not negligible in the other languages. Examples like the following will be studied by spectrography and X-ray motion picture.

English: *nesting, netting, pester, petted; dating, day*
German: *helfen, hellen, Wester, Wetter; Wesen, Weh*
Spanish: *tez, té; pesca, pesa; percha, pera*

12. VOWEL ATTACK AND RELEASE

There is some evidence that English tends to begin initial vowels rather sharply and to end final vowels smoothly, whereas in French initial vowels begin smoothly and final vowels end sharply. It is observed, for instance, that when played backwards English vowels generally have a smooth onset preceded by an [h] sound. French vowels, conversely, have no *h* and have a rather sharp onset. We need to verify this by analysis and synthesis, to investigate the same points in Spanish and German, and to find how these sharp and smooth vocalic features are produced in the larynx. The behavior of the larynx presents puzzling facts, such as the following. What is heard as a glottal stop attack of initial vowels in German shows two very different types of realization on spectrograms, one by vertical spike, indicating a burst or explosion as for stop consonants in general, and the other by a sharp rise in fundamental frequency and no explosion at all.

Since proper attack and release of vowels can play an important role in the auditory impression made by a language, it is of interest to language teaching and deserves further investigation.

13. VOWEL NASALITY

Vowel nasality can be clearly distinctive, as in French, clearly non-distinctive, as in German and Spanish, and have a doubtful status, as in English.

A. *Distinctive nasality.* In French nasality is distinctive, it plays a part in changing meaning: *vin* is different from *vais, sombre* from *sobre, l'un* from *le, banc* from *bas,* largely because of the nasality in *vin, sombre, l'un, banc.* (We say "largely" because other factors also contribute to these contrasts – the tongue position is not quite the same for the orals as for the corresponding nasals; for instance, the vowel of *banc* is less fronted and less open than that of *bas* – see the vowel triangles of Figures 4 and 6.)

In American English, nasality is not generally classed as being distinctive: whether the vowel of *name* is pronounced [neim] or [nẽim] does not affect the

meaning. However, in the sequence "vowel + nasal consonant + oral consonant," as in *bent* [bɛnt], *bunt* [bʌnt], *pond* [pɑnd], *want* [wɑnt], *haunt* [hɔnt], *won't* [wont], *bank* [bæŋk], nasality certainly plays a distinctive role; it contributes to the distinction of *bent* from *bet, bank* from *back* perhaps as much as the nasal consonant does. One even wonders, with certain American speakers, whether the nasality of the vowel does not play the major role. Three experiments have been carried out to verify this possibility.

a) We have cut out the [ŋ] of [bæŋk], recorded on magnetic tape by a Midwesterner, and the amputated word sounded more like *bank* bæ̃k than like *back* [bæk]. This indicates that nasality of the æ̃ might be distinctive.

b) We have done a similar amputation on *bank* and *bent* by synthesis on artificial speech, and with the same result

c) We have added artificial nasality by synthesis to the words *back* and *bet,* after which naive listeners identified them as *bank* and *bent,* not as *back* and *bet.* (Nasalizing a vowel by synthesis is now a standard operation: it consists of decreasing the intensity of the first formant and adding a tone near 250 cps for a fundamental of 120 cps.)

B. *Non-distinctive nasality.* Nasality being distinctive in French, it is essential that non-nasal vowels show no trace of nasality. In the three other languages nasality being non-distinctive or less distinctive, one does not make a special effort to produce purely oral vowels; the result is that vowels may often be nasalized. We are comparing a) the extent of non-distinctive nasality, b) the place of non-distinctive nasality (generally more before nasal consonants, but elsewhere too) among the four languages. This can be observed on spectrograms by loss of intensity in the first formant, as well as on X-rays by the lowering of the velum.

Sentences of the following types, pronounced by native speakers, are being used to study the nasalization of vowels by anticipation of a nasal consonant. For English and German: *The lame lamb is mine/Mein Lamm liegt im Lehm;* for English and French: *Sam in the cab saw that Ann was sad/On blame l'Arabe de ce que l'âne est malade* and *At the camp, the pond sank/La bande campe jusqu'au cinq;* for English and Spanish: *A fin is on a fish/Afines son las islas.* Preliminary results indicate that vowel nasality by anticipation of a nasal consonant is considerable in English, occasional in Spanish, and almost nil in German and French.

In the next and final article, the *consonantal* features of English, German, Spanish and French will be compared.